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## Review

# Consequences of recreational hunting for biodiversity conservation and livelihoods

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## SUMMARY

The widespread activity of recreational hunting is proposed as a means of conserving nature and supporting livelihoods. However, recreational hunting—especially trophy hunting—has come under increasing scrutiny based on ethical concerns and the arguments that it can threaten species and fail to contribute meaningfully to local livelihoods. We provide an overview of the peer-reviewed literature on recreational hunting of terrestrial birds and mammals between 1953 and 2020 (>1,000 papers). The most-studied species are large mammals from North America, Europe, and Africa. While there is extensive research on species' ecology to inform sustainable hunting practices, there is comparably little research on the role of local perceptions and institutions in determining socioeconomic and conservation outcomes. Evidence is lacking to answer the pressing questions of where and how hunting contributes to just and sustainable conservation efforts. We outline an agenda to build this evidence base through research that recognizes diverse social-ecological contexts.

## INTRODUCTION

Human activities are eroding biodiversity and are consequently reducing the benefits provided by nature to people.<sup>1</sup> Unsustainable harvesting and land-use change are historically the most influential drivers of biodiversity loss.<sup>2</sup> When unsustainable, harvesting (e.g., hunting or fishing, see Salafsky et al.<sup>3</sup> for a classification of subthreats within the topic of “unsustainable harvesting”) of species can lead to population declines and, ultimately, to extinction.<sup>4</sup> Infamous examples include the great auk *Pinguinus impennis*, Steller's sea cow *Hydrodamalis gigas*, the passenger pigeon *Ectopistes migratorius*, the marsupial “tiger” *Thylacinus cynocephalus*, and the dodo *Raphus cucullatus*. Conservation actions in response to unsustainable harvesting are multiple and can be multifaceted.<sup>5</sup> Strict protection (i.e., no harvesting permitted) or legislated restrictions on harvesting can be appropriate actions in response to unsustainable rates of harvest, but these can prevent people who live alongside biodiversity from benefiting from nature conservation.<sup>6</sup> A lack of benefit to local people, particularly where it negatively impacts their well-being, is both a problem of inequity and a conservation issue when it results in increased wildlife poaching or persecution.<sup>7</sup> Hence, there is need to apply actions that generate positive benefits for conservation and local people, particularly in

places where pressure on species from unsustainable harvesting is especially severe<sup>8</sup> and poverty is high.<sup>9</sup>

Recreational hunting has long been promoted as a means of generating benefits to conserve and restore biodiversity and contribute to human well-being.<sup>10,11</sup> Proponents of recreational hunting argue that the finances generated can prevent natural habitat conversion and biodiversity loss and help support conservation actions (e.g., anti-poaching measures).<sup>12</sup> For example, recreational hunting in the United States generates funding for state and provincial conservation agencies.<sup>13</sup> In some countries in sub-Saharan Africa,<sup>11</sup> recreational hunting areas cover more land than formally protected areas.<sup>14</sup> In addition, recreational hunting in some contexts provides livelihoods and other benefits (e.g., meat, increased stakeholder collaboration) to local people.<sup>11,15</sup> It is therefore often presented as a means of achieving objectives for both biodiversity conservation and sustainable development.<sup>11</sup> Other conservation benefits of recreational hunting include, *inter alia*,<sup>16</sup> controlling populations of overabundant species<sup>17</sup> and restoring ecosystems<sup>18</sup> and species' populations.<sup>19,20</sup>

Many concerns have, however, been levelled against the role of recreational hunting in supporting biodiversity conservation and livelihoods. One main concern is the sustainability of recreational hunting in the face of increasing human pressures on

biodiversity.<sup>21</sup> There is also uneasiness about the introduction of alien species for hunting purposes and their impacts on ecosystems.<sup>22</sup> Furthermore, the revenue generated from recreational hunting does not always benefit local people living with the biodiversity in question.<sup>11</sup> Increasingly, the practice is considered ethically and morally unjustifiable regardless of any positive outcomes for biodiversity conservation.<sup>23,24</sup> In particular, many consider trophy hunting (i.e., where the hunter retains some or all of the animal's body as a "trophy")<sup>25</sup> to be problematic from an ethical perspective. There is increasing public opposition to the ethical legitimacy of relatively wealthy foreigners hunting large, charismatic mammals such as lions *Panthera leo* and elephants *Loxodonta africana*.<sup>24,26</sup> Some also consider trophy hunting to be unacceptable because it perpetuates the cultural narrative of chauvinism, colonialism, and anthropocentrism.<sup>25</sup> There is therefore a growing movement to influence legislation and ban imports of trophies.<sup>27</sup> Overall, debates centered on recreational hunting are among the most polarizing in conservation science and practice today.<sup>28</sup>

Here, we provide an overview of the peer-reviewed literature on recreational hunting globally. Specifically, we use topic modeling to investigate and summarize the main topics examined and the geographic and taxonomic focus in recreational-hunting research. Drawing on these topics, we consider the diverse implications of recreational hunting for nature conservation and the livelihoods and well-being of people. We conclude by outlining a research agenda to provide evidence-based recommendations for enabling the intersection of sustainability, equity, and ethics when designing best-practice hunting management.

## WHAT IS RECREATIONAL HUNTING?

Hunting can be divided into three broad categories: "subsistence hunting" (food for own consumption), "commercial hunting" (sale of animal products to a consumer community in local, national, or international markets), and "recreational hunting."<sup>29</sup> Recreational hunting can be broadly defined as the pursuit and killing of animals primarily for leisure and enjoyment purposes.<sup>30</sup> However, there may be additional motivations besides recreation, including meat and trophy acquisition, spiritual, social, and cultural motivations, added exercise, the physiological effects of excitement, and the desire to make a direct or indirect contribution to population management, invasive alien species control, and habitat conservation.<sup>31–33</sup> For example, hunting the fox *Vulpes vulpes* in the United Kingdom was largely considered to be a socially and culturally meaningful recreational activity but also a means to control fox populations.<sup>34</sup> Equally, many deer hunters pursue trophies, but also hunt for the experience and for food. Such complexities of motivations can prevent clear distinction between recreational, subsistence, and commercial hunting.<sup>30</sup>

A range of species, particularly mammals and birds, are targeted by recreational hunters who pursue these species by using a range of methods, including bows and arrows, dogs, and guns.<sup>32</sup> Recreational hunting includes both local hunting and tourism hunting.<sup>32</sup> Local recreational hunting is done by hunters that live near the hunting area. Recreational-hunting tourism is done by hunters that travel longer distances from home, often

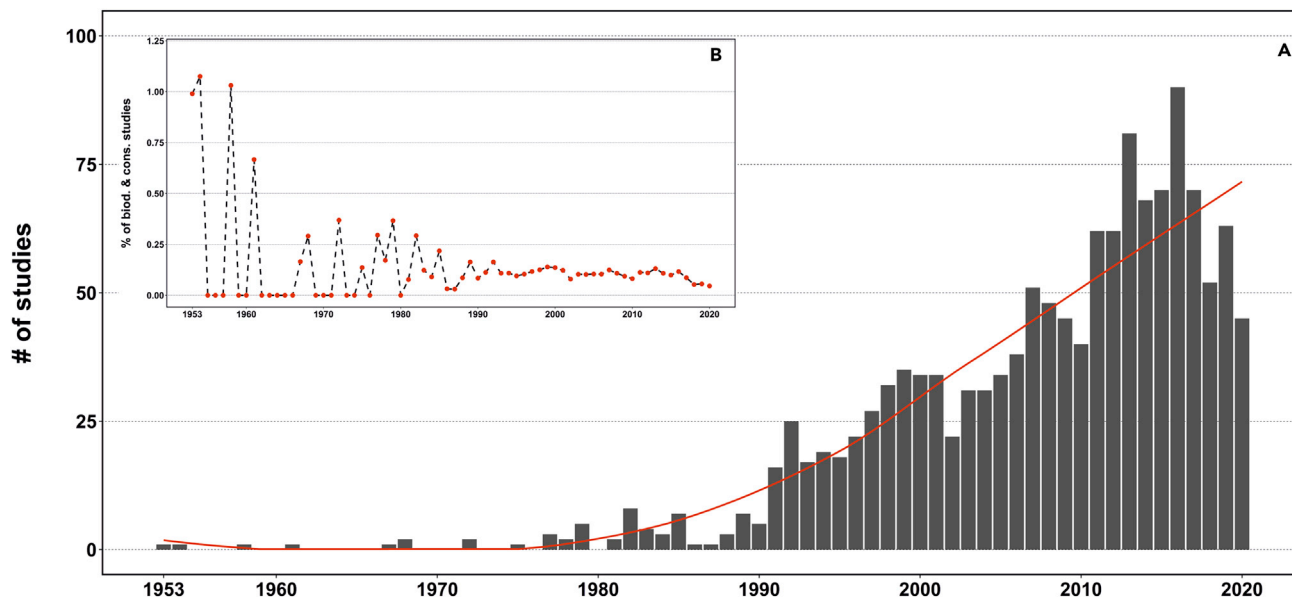
abroad, and who are prepared to pay considerably for the opportunity of hunting particular species.

Recreational hunting is often regulated, with the intention of meeting certain ecological, social, ethical, and sustainability standards (at least in theory).<sup>35</sup> Regulation normally occurs via national or subnational legislation, which recognizes the role of specific authorities for management. Legislation might also be accompanied by local to regional by-laws regulating recreational hunting, and in some instances by local traditional institutions. International regulations also play an important role in the cross-border movements of hunting trophies from certain species. Legislating agencies normally determine the methods for regulating the numbers of animals hunted and/or seasons in which to hunt. Sustainability can be promoted by establishing a fixed hunting quota, by regulating hunting effort temporally and/or spatially, or by limiting the proportion of the population that can be hunted. A review of such regulations goes beyond the scope of our study, and the reader is referred to Rosser<sup>35</sup> for a detailed discussion.

## ETHICS OF RECREATIONAL HUNTING

Recreational hunting is a controversial and contested issue. The public acceptance of any form of recreational hunting, even in relation to invasive alien species,<sup>36</sup> is today lower than it has ever been in the past,<sup>37</sup> with concerns regarding animal welfare and rights dominating the discussion and ethical apprehension on the morality of hunting for pleasure.<sup>38</sup> The ethical arguments against hunting can originate from the perspective of animal welfare focusing on the rights of the individual animal and the morality of eating meat, which contrasts with the land ethic justifying population management via hunting for the greater good of the ecosystem rather than the individual animal.<sup>39</sup> Another ethical debate emerges between primitivist arguments of hunting as an evolved human behavior that implies "trophic responsibility,"<sup>40</sup> and the ecofeminist argument that primitivism marginalizes women's relationship with nature and that recreational hunting is the outcome of the patriarchy's fixation on violence and death.<sup>39</sup> The common justification for recreational hunting as an experiential fulfillment has been argued to be morally inconsistent, because its protagonists create a false hunting ideology given that commoditization of the prey weakens justification regarding the thrill of the chase.<sup>41</sup> Furthermore, there are philosophical arguments that expose the fallacy of attempting to distinguish the morality of sport versus subsistence hunting, and that ethical hunting of any type cannot rely on human constructs and should be instead couched in terms of ecology and evolution.<sup>42</sup>

Trophy hunting in particular is a charged emotional stage, with entire treatises devoted to understanding why elements of society are either strongly supportive of or morally outraged by the idea.<sup>43</sup> Indeed, much of the incentive can be traced to its colonial heritage as an elitist sport, but a sense of accomplishment in terms of skill and physical endurance in conquest of nature red in tooth and claw feature strongly.<sup>43,44</sup> There is still limited direct research on why certain people engage in hunting for amusement, the "thrill of the chase," or a "sense of achievement."<sup>45</sup> Overall, the ethical debates about recreational hunting in conservation science literature have been mostly dominated, implicitly



**Figure 1. Number of studies on recreational hunting published per year**

(A and B) The trendline in red in (A) shows that the number of studies published each year has been steadily increasing over time; (B) shows the percentage of overall studies published in biodiversity and conservation that focus on recreational hunting. The search included items published from 1953 to mid-September 2020, hence the lower number of studies indicated in 2020.

or explicitly, by a set of western-normative ethical perspectives (e.g., deontology, utilitarianism/consequentialism).<sup>24–26,46</sup> Given that perceptions, actions, and relationships with nature are influenced by a diversity of worldviews, ethical commitments, values, knowledge systems, and power relations, there are calls for a more pluralist approach to ethical debates such as this.<sup>47</sup> These approaches acknowledge alternative western positions such as virtue ethics and ethics of care (e.g., Santiago-Ávila and Lynn<sup>48</sup>), as well as other non-Western ethical frameworks—for example, Ubuntu, Buddhism, Hinduism, and *buen vivir* (e.g., Mkono<sup>49</sup> and Gairola<sup>50</sup>).

## HUNTING RESEARCH TOPICS

To assess the current state of knowledge on recreational hunting, and the degree to which the dominant research topics relate to the conservation and livelihood implications of hunting, we conducted a comprehensive key-word search in the Web of Knowledge Core collection to identify peer-reviewed literature related to recreational hunting. The search string comprised 25 key words associated with multiple forms of recreational hunting (see [Supplemental experimental procedures](#)). We included items published from 1953 to mid-September 2020, resulting in 3,882 references. We screened this initial list of articles for relevance based on the content of titles and abstracts. We considered only scientific articles explicitly addressing regulated recreational hunting, therefore discarding articles focusing solely on commercial and/or subsistence hunting. We retained only those articles dedicated to terrestrial ecosystems and mammal and bird species. This screening resulted in 1,342 unique references that we considered for further analysis (see [Data S1](#)). The number of articles published each year has been steadily increasing

over time at a rate similar to the literature focusing on general conservation science ([Figure 1](#)).

Given the large number of studies, we used a natural-language processing approach to identify the dominant topics discussed in the collected articles. We used latent Dirichlet allocation,<sup>51</sup> which is a statistical model that identifies broad topics by ranking key-word patterns across manuscripts. Specifically, topics are identified by detecting key-word patterns within articles and automatically clustering groups of key words that best characterize a set of articles. Words used to discuss a particular topic across all articles tend to occur together more frequently when compared with the rest of the words, while a particular article can discuss more than one topic.<sup>52</sup> The optimal number of topics represents the fewest topics that maximize the information covered as close to the original text as possible<sup>53</sup> (see [Supplemental experimental procedures](#) for detailed methods). Topics were identified based on the title and abstracts of articles in our database (when available;  $n = 1,171$ ), and we list the resultant seven topics in [Table 1](#).

Articles associated with topic 1 address issues around the selective harvesting of individuals, usually in the context of trophy hunting. Selective harvesting can be sustainable,<sup>54</sup> but if poorly managed it can have important ecological, evolutionary, and population consequences. For example, the selective harvesting of bighorn *Ovis canadensis* trophy rams in North America triggered an evolutionary response toward reduced body weight and horn sizes over time because the phenotypic traits targeted by hunters are heritable.<sup>55</sup> Selective harvesting at unsustainable rates can also modify natural sex ratios,<sup>56</sup> especially in sexually dimorphic species when only one of the sexes possesses the traits desired by most hunters, or change population structure when individuals are selectively removed before reaching the age of sexual maturity.<sup>57</sup>

**Table 1. Seven dominant topics discussed in the recreational-hunting literature**

Topic	Description	Top 10 associated key words	No. of articles as dominant topic
1	Ecological, evolutionary, and population consequences of selective harvesting	harvest, population, male, rate, age, size, female, effect, mortality, survival	221
2	Ecological and behavioral consequences of hunting, including activity and movement patterns	area, human, habitat, density, study, forest, pressure, effect, increase, site	158
3	Population dynamics in response to hunting, including assessments of survival rates, reproductive rates, and population trends	management, population, model, estimate, datum, control, base, approach, method, potential	122
4	Hunting as a source of and management tool for invasive alien or conflict species	deer, population, specie, wild, animal, red, number, high, decline, region	150
5	Health and toxicological dimensions of hunting	lead, bird, waterfowl, season, shoot, winter, high, number, source, breed	157
6	Social dimensions of hunting, including hunter attitudes, identities, and preferences	hunter, game, survey, recreational, wildlife, bear, study, hunt, group, provide	159
7	Economic, social, cultural, political, and ethical dimensions of hunting	conservation, trophy, wildlife, lion, local, economic, tourism, community, benefit, resource	204

Hunting can alter the behavior of targeted species. Research associated with topic 2 generally focuses on understanding these behavioral responses. Research suggests that some species, including the white-tailed deer *Odocoileus virginianus*,<sup>58</sup> red deer *Cervus elaphus*,<sup>59</sup> and American black bear *Ursus americanus*,<sup>60</sup> might change their movement patterns in relation to hunting pressure. Another frequent behavioral response of ungulates to hunting pressure is an increase in flight-initiation distances.<sup>61</sup> There is also evidence that hunting can cause species to change their foraging behavior and habitat selection, and induce physiological stress (e.g., Bryan et al.<sup>62</sup>). However, not all species respond negatively to hunting (e.g., Neumann et al.<sup>63</sup>), and research associated with this topic often focuses on developing solutions to ensure sustainable hunting practices by minimizing the impact of hunting on the target species' behavior.

Articles associated with topic 3 explore the impacts of hunting on population dynamics and provide assessments of drivers of population status and trends, including hunting. Much of this research focuses on estimating population parameters necessary to understand temporal population dynamics, including breeding success, age of first breeding, survival, and population density (e.g., Devineau et al.<sup>64</sup> and Martinoli et al.<sup>65</sup>). Hunting rates are also often reported (e.g., Angulo and Villafuerte<sup>66</sup>). Research associated with this topic is essential to evaluate the long-term sustainability of populations of hunted species and to propose measures to ensure sustainability, such as the establishment of hunting controls and quotas (e.g., Dolman et al.<sup>67</sup>).

Topic 4 covers articles mainly dealing with hunting as a source of, and population management tool for, invasive alien or conflict species. Recreational hunting has been a driver for the introduction of game species—namely ungulates—in many regions of the world; the red deer in New Zealand<sup>68</sup> and chital *Axis axis* in Argentina<sup>69</sup> are two examples. These species can host zoonoses and parasites,<sup>70</sup> and cause ecosystem impacts when their pop-

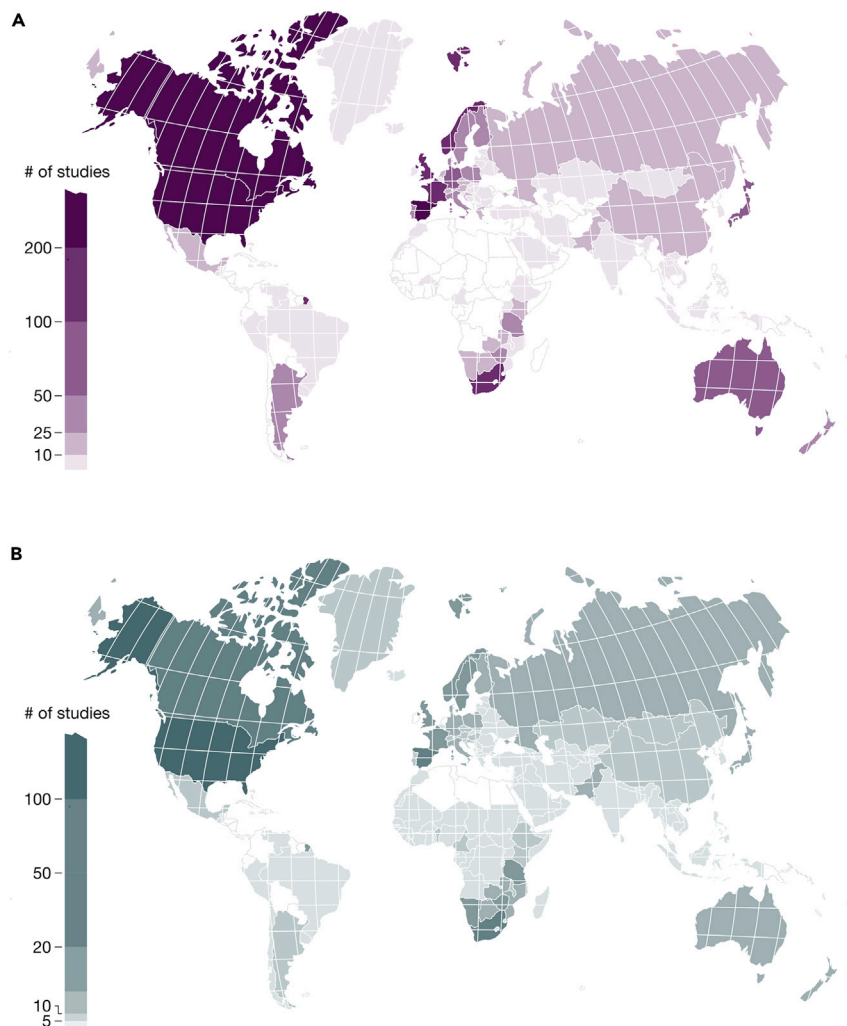
ulations expand in the absence of hunting. Articles associated with this topic address these issues<sup>71</sup> and how hunting can sometimes emerge as a tool to help control invasive or conflict species' populations and impacts.<sup>72</sup> Similarly, research in this topic addresses how hunting can be a source of conflict with wild species, namely predators, and a means used to control human-wildlife conflicts.<sup>73</sup>

Research that addresses the health and ecotoxicological dimensions of hunting constitutes topic 5. Health concerns associated with the consumption of wild meat have recently gained additional attention in the context of the COVID-19 pandemic, but similar concerns related to the consumption of game meat have been a topic of research for many years. Examples include analyzing the prevalence of pathogens in wild meat (e.g., Paulsen et al.<sup>74</sup>) or game meat compliance with health and safety regulations intended for global markets.<sup>75</sup> Lead pollution from hunting can also have detrimental consequences for the health of wild animals and ecosystems. Much of the research associated with this topic addresses contamination associated with the use of lead ammunition in hunting, with potential consequences for species, ecosystems, and even humans (e.g., Hampton et al.<sup>76</sup>).

Topic 6 includes research addressing hunters and their attitudes, identities, and preferences, among other factors. Hunters form a sizable and diverse group of wildlife-recreation enthusiasts, including people with different interests, skills, education, views, and various degrees of specialization and engagement.<sup>77</sup> Much of the research associated with this topic describes these characteristics, often in the context of the economic importance of hunting. This includes understanding preferences for hunting experiences (e.g., Schroeder et al.<sup>78</sup>), evaluating harvest expectations (e.g., Bradshaw et al.<sup>79</sup>), exploring hunter identities and views on different approaches to hunting,<sup>80</sup> or assessing willingness to pay or travel for hunting.<sup>81</sup>

The economic, social, cultural, political, and ethical dimensions of hunting are the focus of research linked with topic 7.





**Figure 2. Geographic distribution of recreational hunting research**

(A and B) The maps show the country contribution (as number of studies) to research, based on authors' affiliations of the studies (A) and countries where the studies were done (B).

thors of the identified papers had affiliations from 87 countries across all continents (Figure 2A), while 147 countries across all continents were researched in these studies (Figure 2B). The United States (first), Canada (second), and Spain (third) had both the most articles that reported author affiliations in these countries and the most articles that had a research focus in these countries. North America, Europe, and Africa were the most researched continents, although this might be partially an artifact of our review only including studies published in English. Research focusing on Africa and Asia was done by authors based in Africa or Asia, respectively, as well as by authors based in Europe, North America, and Oceania (Figure 3). Research focusing on North America, Europe, Oceania, and South America was instead mainly done by authors based in those continents.

Geographic differences are evident among the dominant research topics (Figure 4 and Table 1). While all topics were researched across Africa, North America, and Europe, topic 7 (social and ethical dimensions) was more common in Africa, while topic 6 (hunter perceptions) was more common in North America and topic 4 (population management) was more common in Europe. There were not enough studies from the other continents to provide meaningful continent-specific results.

Much of this research highlights how hunting can provide a range of contributions, both positive and negative, to humans and nature. For example, it can be a source of revenue, which can be used to support local economies<sup>82</sup> and the conservation and restoration of threatened species and habitats.<sup>14</sup> Certain hunting practices are also considered part of local cultural heritage in different regions and therefore have deep cultural value.<sup>83</sup> On the other hand, hunting can also be a source of conflict, owing, for instance, to issues associated with land tenure and benefit access by local people.<sup>84</sup> More broadly, hunting is also the focus of heated political and ethical debates that permeate the peer-reviewed literature. Articles debating the ethical and political dimensions of hunting, particularly trophy hunting (e.g., Hsaio<sup>85</sup>), are included in this topic.

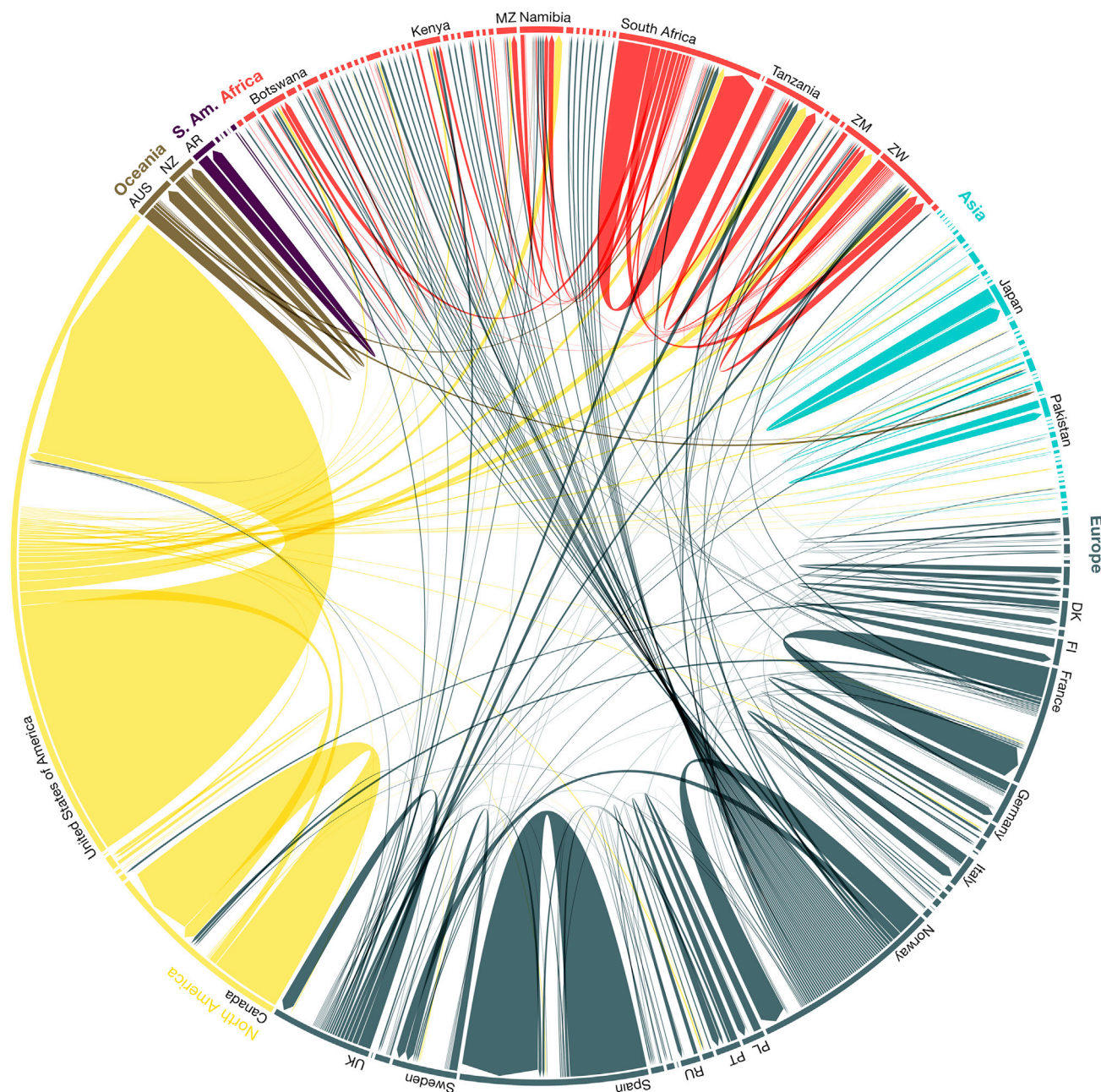
## GEOGRAPHIC DISTRIBUTION OF HUNTING RESEARCH

To assess the geographic distribution of peer-reviewed knowledge generation on recreational hunting, we considered where researchers were affiliated, where their research took place, and which topics were commonly researched in these places. The au-

## TARGETED SPECIES

To identify the focal species in studies on recreational hunting, we extracted species information (where present) from the articles (review papers were excluded to avoid repetition of studies). There is a notable focus on certain species groups in the literature. Eight family groups were the focus of over 50 research articles: Cervidae ( $n = 297$  papers), Bovidae (169), Anatidae (130), Felidae (117), Phasianidae (69), Suidae (68), Canidae (64), and Ursidae (62).

Just 12 species were the focus of 50 or more studies each, comprising 37% of all studies mentioning targeted species (Figure 5A). There was a strong bias toward mammals (74% of studies) compared with birds (26% of studies; Figure 5B). Eleven of the 12 most commonly studied species were large mammals, and just two are considered threatened (lion and leopard *Panthera pardus*), with the remainder listed as Least Concern by



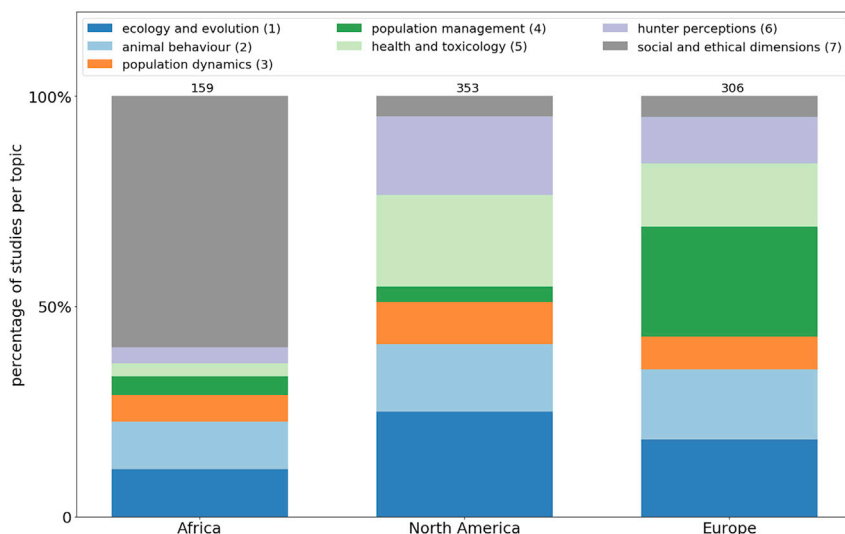
**Figure 3. Global connections of recreational hunting research**

Cords represent the connections between the countries where the authors were affiliated and where the research was done. Arrows point towards the country in which the study was done. S. Am., South America; AR, Argentina; AUS, Australia; DK, Denmark; FI, Finland; MZ, Mozambique; NZ, New Zealand; PL, Poland; PT, Portugal; RU, Russia; UK, United Kingdom; ZM, Zambia; ZW, Zimbabwe.

the International Union for the Conservation of Nature (IUCN) (Figure 5). These 12 species are either widely hunted in Europe and North America or a target of trophy hunting in Africa. The three most-studied species—red deer, white-tailed deer, and wild boar *Sus scrofa*—have all been introduced for hunting in several locations globally (e.g., wild boar and red deer introduced to the Americas and Oceania; white-tailed deer introduced to Europe and New Zealand), and hunting is now used as a means of controlling their populations.<sup>17</sup>

We identified studies that assessed the impact of recreational hunting on the population abundance of targeted species as one measurable dimension of species conservation (excluding reviews, hunting to control problem species, and models predicting future impacts of hunting). Methods of assessment included long-term camera surveys, transect surveys, monitoring of radio-collared individuals, mark-recapture, and official records. Just 35 species had more than one study each assessing the impact of hunting on abundance (Figure 6). This highlights that





**Figure 4. Stacked bar chart showing the relative percentage of studies assigned to broad recreational hunting research topics, per continent**

Total number of studies per continent is shown above each stacked bar. Topics were identified by using a latent Dirichlet allocation technique and are further explained in Table 1.

ada goose *Branta canadensis*), with some studies finding a negative impact of hunting on abundance and others not (Figure 6).

### IMPLICATIONS OF HUNTING FOR NATURE CONSERVATION

A holistic assessment of the effects of recreational hunting on conservation requires considering both the direct effects of hunting

despite the large body of literature assessing the impacts of recreational hunting on targeted species (Table 1, topics 1 to 3), few studies explicitly assess the consequences for abundance trends (a commonly used indicator of conservation effectiveness,<sup>86</sup> excluding cases where the objective is to cause population declines of problem species). Recreational hunting consistently caused abundance declines for one species (reindeer *Rangifer tarandus*). Findings were variable for a third of studied species, with some but not all studies concluding that hunting caused declines in abundance. This variability in conclusions could reflect the diversity in studied locations (Figure 2B) and time periods (Figure 1). For the remaining species, there was no evidence of negative impacts of recreational hunting on abundance. As a note of caution, the few studies and prevalence of inconclusive results for many species means that a lack of evidence of negative impacts on abundance cannot be interpreted as evidence of sustainability.

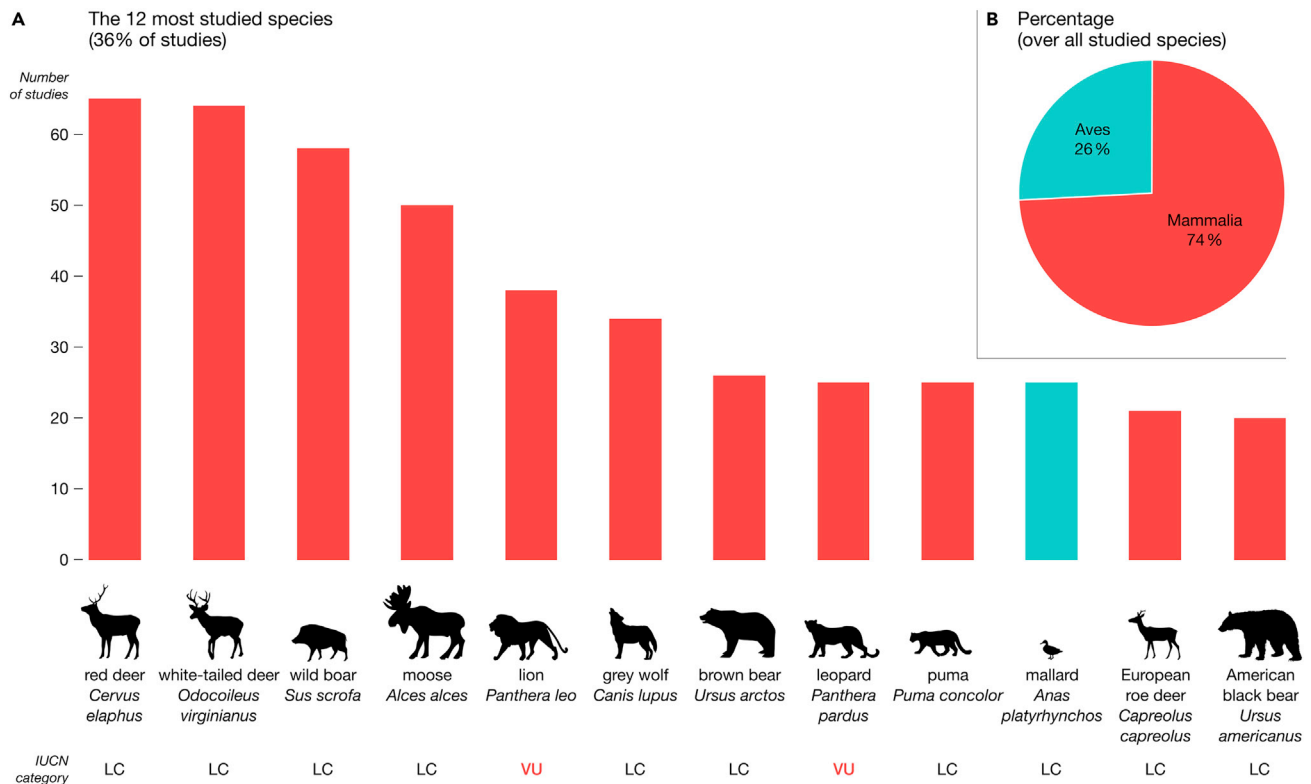
Most studies (89%) assessing population impacts of hunting focused on mammals, and over half of these were on large African mammals (Figure 6). The most-studied species were two large predators—lion and leopard—which are hunted for trophies in 12 and 10 countries, respectively.<sup>11</sup> The mixed results for these species (some studies showing negative impacts and others not) demonstrate differences among and within countries regarding the regulation of trophy hunting and the appropriateness of hunting quotas (topic 3).<sup>87–90</sup> Sustainability challenges include unscientific bases for setting quotas, excessive quotas and offtakes, lack of restrictions on the age of individuals that can be hunted, and other issues of poor governance (e.g., uncertain property rights, corruption).<sup>91–93</sup> In some cases recreational hunting is not the main threat to species, but can exacerbate the larger impacts from poaching and habitat loss (e.g., trophy hunting can result in population declines if high poaching pressure is not considered when setting quotas).<sup>94,95</sup>

Three carnivore species in Europe/Asia (brown bear *Ursus arctos*, gray wolf *Canis lupus*, fox) and one in North America (puma *Puma concolor*) similarly showed mixed results, as did two North American bird species (bobwhite quail *Colinus virginianus*, Can-

ing on the sustainability of the targeted species, as well as the indirect effects of this hunting on ecosystems more generally. Species can be overharvested through recreational hunting, resulting in population declines (Table 1, topic 3), or hunting can have evolutionary and behavioral consequences for the target species (topics 1 and 2). Hunting can disturb other species, ecosystems, and ecological processes (topic 4), or cause environmental pollution and poisoning of other species due to discarded ammunition (topic 5). However, the socioeconomic benefits generated by hunting can contribute to a species' conservation and even reintroduction into areas of previous extirpation, and support habitat conservation and restoration (topic 7). Recreational hunting is also a tool for controlling overabundant and problem species, which can minimize their negative impacts on other species (topic 4).

The interactions between recreational hunting and biodiversity conservation are often context dependent and necessitate the careful management of positive and negative conservation trade-offs.<sup>90</sup> For example, several studies highlight the conservation benefits and costs that arise from trophy hunting (topic 7). On the one hand, legislation provides private landowners and communities in some southern African countries with user rights over wildlife on their land, allowing them to generate revenues through sustainable-use activities.<sup>96</sup> This legislation, together with the growing ecotourism and trophy-hunting markets and low viability of livestock farming in arid areas, has resulted in a transition from livestock ranching to wildlife ranching over large tracts of land in recent decades, helping restore indigenous flora and fauna.<sup>82,96,97</sup> Approximately 1,394,000 km<sup>2</sup> of land is dedicated for trophy hunting in sub-Saharan Africa, exceeding the area encompassed by national parks there.<sup>11,98</sup> The white rhino *Ceratotherium simum* is an interesting example of a species whose population recovery became tractable via trophy hunting. The opportunity to purchase rhinos from their last remaining population in Hluhluwe-iMfolozi Park, and offer limited trophy hunting at high prices, incentivized South African landowners to conserve and trade rhinos, resulting in their reintroduction across more than 16,000 km<sup>2</sup>.<sup>99</sup>





**Figure 5. Number of studies focusing on the recreational hunting of specific species**

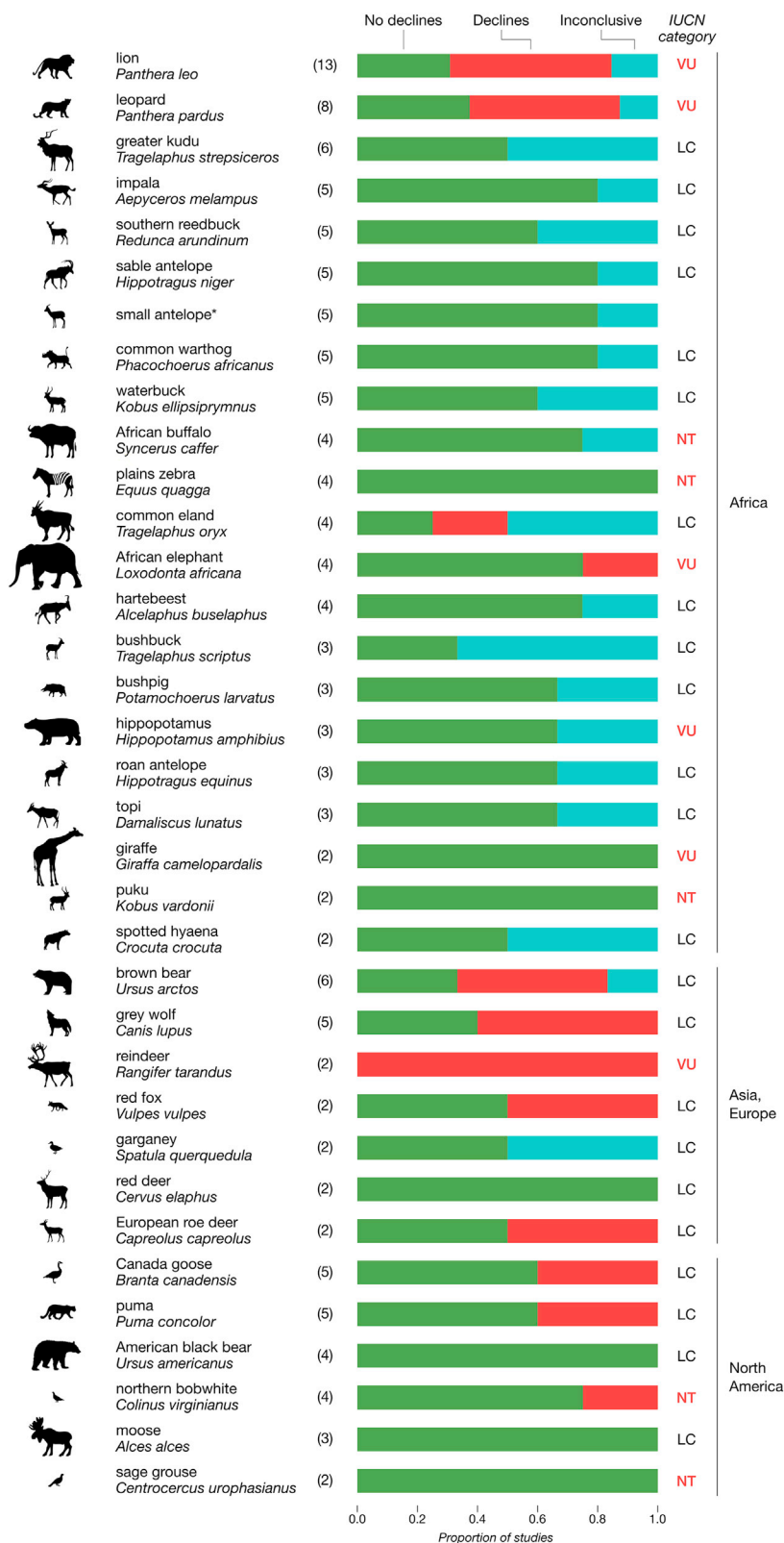
(A and B) The 12 most-studied species (A), and the percentage of studies dedicated to mammals and birds (B). IUCN Red List threat status: LC = Least Concern; VU = Vulnerable. Silhouette images are from [phylopic.org](https://www.phylopic.org) and in the public domain, except for *Ursus americanus* ([creazilla.com](https://www.creazilla.com); Creative Commons Attribution 4.0; by B. Comix) and *Ursus arctos* ([pixabay.org](https://www.pixabay.org); free for commercial use [Pixabay-License]).

On the other hand, evidence shows that unsustainable hunting of lions and leopards in some places has posed (or continues to pose) serious risks to the conservation of these species (Figure 6), calling for policy interventions to make this hunting more sustainable.<sup>20,88</sup> In some contexts (e.g., leopard in South Africa), such policy interventions have been implemented.<sup>90</sup> Predators are also sometimes killed because they prey on species that are the target of trophy hunting, and the proliferation of fences around wildlife ranches can be detrimental to wider conservation efforts.<sup>100</sup> Furthermore, the hunting of captive-bred lions on private land in South Africa has come under heavy criticism.<sup>11</sup>

Recreational hunting underpins the North American model of wildlife conservation whereby hunting is proposed as an ethical and conservation-motivated tool.<sup>10</sup> Since 1937, fees from waterfowl hunters<sup>101</sup> have made it possible to conserve or restore more than 50,000 km<sup>2</sup> of habitat in some of the most important areas for duck and geese conservation in the United States and Canada.<sup>102</sup> In addition, recreational hunting has now become the primary product of the land for many landowners in the United States.<sup>103</sup> In North America, hunting of abundant herbivores and carnivores for management purposes is considered mostly sustainable,<sup>13,104,105</sup> which is supported by our findings for moose and American black bear (Figure 6). However, research quantifying the impacts of hunting on populations is lacking for many species, and negative impacts have also

been documented for puma and Canada goose (Figure 6) (e.g., Packer et al.<sup>106</sup>).

Europe has a long history of using hunting as a tool to support biodiversity conservation.<sup>107</sup> In Denmark, for example, hunting is an important motivation for landowners to retain and enhance multifunctional landscapes through afforestation of previous farmland and the establishment or restoration of lakes and ponds.<sup>108</sup> However, habitat management to benefit hunted species is not always good for other species.<sup>109</sup> Hunting has created the conditions for the introduction of invasive species such as sika deer *Cervus nippon* and cotton-tail rabbit *Sylvilagus floridanus* in Europe (topic 4), some of which have damaged ecosystems.<sup>22</sup> Similar to findings for Africa, the dynamic behavioral and population ecology of large predators can present challenges for achieving sustainable recreational hunting in Europe (topics 1 to 3)<sup>110</sup> (e.g., gray wolf, brown bear, fox—Figure 6).<sup>111,112</sup> The benefits of hunting game birds for biodiversity conservation vary across Europe.<sup>113</sup> Most evidence suggests that habitat management for game birds is positive for other species in agricultural systems (topic 7),<sup>113</sup> and hunters in Europe also help scientists collect data that can be used to monitor biodiversity trends.<sup>114</sup> By contrast, conservation concerns include the illegal killing of protected predators by those interested in the production of game species, and the release of farm-reared birds into the wild to augment populations.<sup>113</sup>



**Figure 6. Impact of recreational hunting on the population abundance of targeted species**

Depicted is the proportion of studies that found inconclusive evidence, evidence of population declines, or evidence of no population declines. Number of studies is indicated in parentheses next to species name; only species with >1 study are included. IUCN Red List threat status: LC = Least Concern; VU = Vulnerable; NT = Near Threatened. \*Small antelope refers to steenbok *Raphicerus campestris*, oribi *Ourebia ourebi*, grysbok *Raphicerus sharpei*, duiker *Cephalophus* sp. or *Sylvicapra grimmia*, and dik-dik *Madoqua kirkii*. Silhouette images are from [phylopic.org](https://www.phylopic.org) and in the public domain, except: *Kobus vardonii*, *Tragelaphus oryx*, *Alcelaphus buselaphus*, *Kobus ellipsiprymnus*, *Phacochoerus africanus*, *Redunca arundinum* ([phylopic.org](https://www.phylopic.org); Creative Commons Attribution 3.0; by J.A. Venter, H.H.T. Prins, D.A. Balfour, R. Slotow, and M. Keesey); *Damaliscus lunatus* ([phylopic.org](https://www.phylopic.org); Creative Commons Attribution-NonCommercial-ShareAlike 3.0; by Lukasiniho); *Vulpes vulpes* ([phylopic.org](https://www.phylopic.org); Creative Commons Attribution-NonCommercial-ShareAlike 3.0; by A. Caravaggi); *Tragelaphus strepsiceros* ([Wikimedia.org](https://www.wikimedia.org); Creative Commons Attribution-Share Alike 4.0 International; by user "Six Plus by Libé"); *Ursus americanus* ([creazilla.com](https://www.creazilla.com); Creative Commons Attribution 4.0; by B. Comix); *Ursus arctos* ([pixabay.org](https://www.pixabay.org); free for commercial use [Pixabay-License]).

Evidence on the implications of recreational hunting for nature conservation in other continents is more limited, but at least for Asia and South America this might arise from a dearth of English-language publications. In Asia, evidence suggests that recreational hunting might affect population dynamics and sex ratios of harvested populations in several countries (topics 1 and 3; Figure 6).<sup>115</sup> By depleting herbivores, recreational hunting can also indirectly affect the conservation of threatened carnivores.<sup>116</sup> However, in the absence of carnivores in the ecosystem, recreational hunting is also used to control populations of abundant herbivore species (e.g., Japan), therefore reducing damage to natural habitats (topic 4).<sup>117</sup> In Oceania, recreational hunting is mainly done to control overabundant species, to decrease crop grazing and competition with livestock, and to help conserve native habitat by controlling invasive species (e.g., red deer).<sup>68</sup> However, some of these invasive species were introduced for hunting, making hunting both the cause and the solution (topic 4).<sup>68</sup>

## IMPLICATIONS OF HUNTING FOR LOCAL PEOPLE AND ECONOMIES

Just two of the seven main topics in the literature focus primarily on the human dimensions of hunting, with one (Table 1, topic 6) focusing on the hunters themselves (particularly in North America) and the other (topic 7) focusing on the socioeconomic outcomes of (particularly trophy) hunting for local people and economies (particularly in Africa—Figure 4). Worldwide, recreational hunting has been an integral component of people's diets and cultural heritage, supporting livelihoods and contributing to food security.<sup>118</sup> In addition, hunting has been important to foster local social-ecological knowledge, to develop meaningful relationships with nature and sense of place,<sup>118</sup> to elicit pro-environmental behavior, and to enable the evolution of formal and informal institutions among hunters.<sup>119</sup> Hunting is used to mitigate human-wildlife conflict by controlling populations of predators and large herbivores that pose a threat to human life, livestock, and agriculture (e.g., Delibes-Mateos et al.<sup>120</sup>), although it is not always effective (e.g., wild boar;<sup>121</sup> topic 4). However, recreational hunting can also have negative implications for the health of local people by exposing them to the spread of zoonotic diseases,<sup>74,75</sup> and to contamination by lead ammunition<sup>76</sup> both from direct contact with wildlife and from the consumption of game meat (topic 5).

Recreational hunting can generate revenue that accrues to landowners, state conservation agencies, governments, local communities, and/or the private sector, with the potential (although not always realized) to provide livelihood opportunities and funding for conservation (topic 7). Some studies have quantified the hunting revenue accrued to private landowners and state conservation agencies (and means of enhancing this revenue; topic 6) in North America,<sup>102,122</sup> Europe,<sup>123–125</sup> sub-Saharan Africa,<sup>11,82,98</sup> and Oceania.<sup>126–128</sup> The contributions that recreational hunting makes to broader economies in these regions have also been estimated.<sup>122,129</sup> Largely unique to sub-Saharan Africa, there is also a body of literature assessing the revenue accrued to local communities via hunting on community land or payments to communities residing within or adjacent to state hunting areas.<sup>130–132</sup> By contrast, few studies have

assessed the economic contributions of hunting in Asia or Central and South America (but see Aryal et al.<sup>115</sup> and Baur et al.<sup>133</sup>).

A commonly mentioned threat to hunting revenue sources in southern Africa is the growing pressure to ban trophy hunting (done predominantly by foreign hunters).<sup>11</sup> In North America and Europe, by contrast, the declining number of local recreational hunters in recent decades is noted as a concern for revenue generation (e.g., in the United States<sup>134</sup> and Europe<sup>17,135</sup>). In addition to fewer hunters potentially reducing incentives for habitat and wildlife protection on private land, declines in waterfowl hunting in the United States are predicted to result in 28–139 km<sup>2</sup> less land being restored each year due to lower revenues from hunting stamps.<sup>136</sup> The North American model of wildlife conservation has also been criticized, however, for focusing its rhetoric on hunters and wildlife managers (topic 6) and excluding non-consumptive users, policy-makers, and other conservation practitioners.<sup>137</sup> The negative consequences of declining hunter numbers in Europe for the management of problem species have also been discussed.<sup>17,135</sup>

The contribution of recreational hunting to livelihoods and conservation is also influenced by the costs of conserving wildlife (and who bears these costs; topic 7).<sup>11</sup> For example, trophy hunting is estimated to generate US\$138–1,091 km<sup>−2</sup> across sub-Saharan Africa, while estimates of the funding requirements for effective management of protected areas are \$460–\$2,048 km<sup>−2</sup>.<sup>138</sup> Where wildlife authorities depend heavily on hunting income to fund strict protected areas, the revenue can be insufficient to manage hunting blocks or to provide meaningful contributions to local communities.<sup>132,139</sup> The limited viability of trophy hunting in some regions relates to the few remaining trophy species, European Union bans on imports of trophies, as well as increased costs of mitigating threats related to poaching, agricultural encroachment, and growing climate insecurity.<sup>131,140</sup> Elsewhere, while wildlife-based tourism (the primary alternative wildlife land use) is limited to areas that combine good infrastructure and abundant wildlife or spectacular scenery,<sup>141</sup> trophy hunting can enable biodiversity conservation to be a viable land use across many community conservancies<sup>130</sup> and private ranches.<sup>142</sup>

There can be important power dynamics influencing who benefits from hunting and how. Biodiversity in general, and hunters' preferred species in particular, have been increasingly commodified (i.e., neoliberal conservation), often through the imposition of governance models that might not be suited to local contexts.<sup>84,143</sup> In some regions in sub-Saharan Africa, for example, recreational hunting secured property rights and hunting quotas while subsistence hunting by indigenous and local people was banned and considered to be poaching, potentially leading to social conflicts and compromising local support for conservation.<sup>84,144</sup>

Different initiatives have aimed to address these issues by promoting the participation of local people in the governance of natural resources, including community-based natural resource management projects in southern Africa.<sup>145</sup> Positive outcomes include the creation of employment opportunities, increased stakeholder collaboration, the emergence of local co-management institutions, the engagement of communities in policy making and monitoring, and improvement of local people's attitudes toward wildlife.<sup>145,146</sup> However, power dynamics can also be a

challenge for these initiatives,<sup>84,147</sup> with imbalances in equitable distribution of benefits, market challenges, and dependence on tourism investors and trophy-hunting companies.<sup>148</sup> Failing to address these issues in a fair way with communities can potentially result in people's disempowerment and active protests to programs.<sup>84</sup>

A challenge to understanding the implications of recreational hunting for local people, and how this interacts with conservation, is the lack of clear counterfactuals—would local people and nature have been better or worse off or the same in the absence of recreational hunting? Historic and recent bans on trophy hunting allow for one form of counterfactual analysis, although such research is limited to a few examples (we therefore urge caution when attempting to extrapolate these findings to other contexts). In Botswana, a hunting ban implemented in 2014 has been reported to affect local communities by reducing income, employment opportunities, and access to game meat (reducing food security).<sup>145</sup> This ban was subsequently lifted in 2019. In the case of Kenya where a ban on trophy hunting has been in place since the late 1970s, there is potential support for the return of trophy hunting to alleviate human-wildlife conflict and enable access to benefits from hunting tourism.<sup>149,150</sup> Finally, assessments of the potential effects of hypothetical bans on trophy hunting in Namibia and South Africa have revealed unintended negative consequences for biodiversity conservation, economies, and livelihoods.<sup>130,146,151</sup>

Overall, hunting practices and policies are highly context dependent and are driven by a diversity of values, needs, identities, and worldviews. Despite this, existing research is limited in quantifying local perceptions, experiences, power relationships, and meanings on recreational hunting and its main stakeholders at different scales.<sup>147</sup> A plural-valuation approach (e.g., Zafra-Calvo et al.<sup>152</sup>) could contribute to recognizing and integrating diverse value systems, needs, and ethical positions to foster dialog, share understanding, and identify socially acceptable hunting practices that would maximize the benefit to people and nature.

## OUTLOOK AND CONCLUSIONS

While the literature on recreational hunting is extensive, there are clear biases toward certain continents, species, and topics, and in many cases to species or populations that are not under imminent threat of extinction (Figures 5 and 6). The focus on large mammals reflects a common bias in conservation research.<sup>153</sup> This research bias also mirrors a focus on large charismatic mammals in the literature on ethical concerns about recreational hunting, and trophy hunting in particular (e.g., Vucetich et al.,<sup>24</sup> Batavia et al.,<sup>25</sup> and Ghasemi<sup>46</sup>). Surprisingly, despite the extensive literature on recreational hunting, the evidence to address some of the most pressing academic and societal questions (e.g., when is recreational hunting sustainable, and who benefits from it?) is still limited. Assessing the role of recreational hunting in diverse social-ecological systems is critical to informing equitable ecosystem conservation and restoration approaches that provide ecosystem services according to local people's values and needs.

While hunting is commonly mentioned as a threat to species listed in the IUCN Red List,<sup>2</sup> it is not always clear whether the

threat is from legal forms of hunting or from poaching (i.e., illegal hunting). Many studies research the impacts of recreational hunting on the ecology and evolution of the targeted species. Fewer assess the consequences for the abundance of species of conservation concern, differentiating between the impacts caused by recreational hunting versus poaching. Such assessments are needed to quantify the implications of recreational hunting for the sustainability of targeted species in diverse contexts. Similarly, it remains important to consider the interactions between recreational hunting and other anthropogenic threats to biodiversity (e.g., habitat loss and climate change), because synergistic processes between hunting and such threats could elicit population declines even in cases where hunting is considered sustainable. Such research should also focus on less charismatic species that are covered poorly in the current peer-reviewed literature, as well as assessing the impacts of recreational hunting on non-targeted species and ecosystems (e.g., by better investigating the consequences of hunting large carnivores on predator-prey relationships and their cascading ecosystem effects).

Beyond assessing the implications of recreational hunting for the conservation of targeted species, our analysis reveals a need for research that provides empirical evidence (ideally with counterfactuals) for claims that hunting increases the quantity and quality of ecosystem conservation. Many studies quantify the revenues generated by hunting, but few demonstrate explicit links between these revenues and conservation actions and outcomes (e.g., funding to anti-poaching and reductions in poaching, respectively). Similarly, research should focus on assessing the contributions of recreational hunting areas to global and national biodiversity conservation objectives, and the quality of management and its impact on biodiversity conservation in these areas. This would provide a better proxy for assessing the role of recreational hunting in supporting biodiversity conservation, beyond the simple metric of total area that is conserved on land dedicated to recreational hunting.

Another important topic of research we identified concerns the health and toxicological dimensions of recreational hunting. The ongoing COVID-19 crisis has renewed attention on zoonotic diseases originating from wild animals. On the one hand, recreational hunting could increase the risk of human exposure to zoonotic diseases.<sup>74,75</sup> On the other hand, reduced tourist hunting in the absence of revenue-generating alternatives could result in local people relying more heavily on bushmeat consumption and thus increasing the risk of future pandemics.<sup>154</sup> Effective conservation of species and habitats has also been directly linked to decreases in the number of viruses that animals share with humans, meaning that recreational hunting could minimize the risk of future pandemics in contexts where it contributes to funding ecosystem conservation and restoration.<sup>155</sup> Future research needs to investigate the potential connections between recreational hunting and zoonotic disease risks, accounting for these complexities.

While there is a large body of research focused on setting and assessing hunting regulations such as quotas to promote sustainability, there is comparably little research investigating the role of local institutions (i.e., rules, norms, and traditions) in promoting hunting that is both sustainable and beneficial to local people (but see Bollig,<sup>97</sup> Tsas-Rolfes,<sup>119</sup> and Dowsley<sup>156</sup>). There



is considerable potential for the common-pool resource literature to contribute theoretical insights and analytical tools to understand the interface of social and ecological dimensions of wildlife governance,<sup>157</sup> yet the intersection of wildlife studies and commons scholarship is not well studied.<sup>158</sup> Neither are there many studies that consider conservation and social implications of hunting concurrently, despite their obvious connections. There is a need to engage the commons literature and apply a social-ecological approach to understanding the contexts in which recreational hunting can provide benefits for both people and nature.

Furthermore, there is a need to assess the moral complexity of recreational hunting and to consider the perceptions, experiences, power relationships, and meanings of recreational hunting for people in diverse contexts. Raising (self-)awareness of these ethical issues among the scientific community and the general public would contribute to the discussion, facilitating dialog and shared understanding of the complexity and context dependency around recreational hunting. Promoting legislation in diverse sociocultural contexts in reaction to western-oriented values without adequately consulting local people could have detrimental effects on the hunted species and local people until sustainable alternatives to recreational hunting are identified. It is also important to determine whether benefits from hunting make people more tolerant of the costs of living with biodiversity, and thereby create an incentive for conservation among local communities,<sup>5</sup> recognizing that benefits and costs are not only monetary.

The decreasing numbers of hunters in Europe and the United States, the increasing calls to ban trophy hunting in Africa, and the COVID-19 pandemic all demonstrate the danger of conservation and local livelihoods relying heavily on revenues from tourism. Therefore, it is increasingly evident that alternative or at least additional mechanisms for funding conservation need to be identified.<sup>154</sup> Research could also assess whether recreational hunters would be willing to pay more to compensate for diminished demand for hunting while also reducing pressure on targeted species.

Our results should be considered with the following limitations in mind. First, we only focused on peer-reviewed articles available in English, while many contributions on recreational hunting are found in gray literature and in other languages. For this reason, we consider our work as a first step toward a more comprehensive review of all literature. Second, the breadth of the literature and dominant topics prevented us from doing meta-analyses to quantify the evidence around each topic. We suggest that the topics we identified in this study could serve as a basis to do more focused, topic-specific systematic literature reviews and other analyses. Future studies doing similar assessments should now focus on the literature devoted to “subsistence hunting” and “commercial hunting.” Future studies should also attempt to define different types of hunting based on motivations and regulations.

In conclusion, our assessment of the global peer-reviewed literature on recreational hunting highlights that empirical evidence on the contribution of recreational hunting toward meeting both biodiversity and social objectives does not yet adequately account for the diversity of contexts and worldviews. The need for such evidence is urgent given declining numbers of recrea-

tional hunters in some regions and increasing opposition to trophy hunting in others. The research agenda we propose to address this knowledge gap emphasizes the importance of considering the influence of local social-ecological dynamics on hunting outcomes, and the voices of the people co-existing with wildlife.

## SUPPLEMENTAL INFORMATION

Supplemental information can be found online at <https://doi.org/10.1016/j.oneear.2021.01.014>.

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## AUTHOR CONTRIBUTIONS

Original Idea, E.D.M. and C.J.A.B.; Formal Analysis and Investigation Software, R.A.C. and R.K.; Data Curation, E.D.M., H.S.C., R.A.C., and A. Haukka; Visualization, E.D.M., H.S.C., R.K., C.F., and A. Haukka; Writing – Original Draft, E.D.M., H.S.C., R.A.C., G.C.-C., and A. Hausmann; Writing – Review and Editing, E.D.M., H.S.C., R.A.C., G.C.-C., C.F., A. Haukka, A. Hausmann, R.K., and C.J.A.B.

## DECLARATION OF INTERESTS

The authors declare no competing interests.

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